Survey and Analysis of Flashover Accidents on Icing Insulators in EHV Transmission Lines in China

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Abstract: The icing and flashover of HV transmission lines were always the severe danger to power system in China. In order to display the characteristics of flashover accident and its harm to the paper survey the typical flashover accidents of ac 500KV and dc ±500kV transmission lines in recent decades. Firstly, the conditions and characteristics of icicleover accidents were surveyed, secondly, the reasons were analyzed and the rules were concluded, thirdly, the measures to chasten and decrease the accidents were advanced as the existing results.

Keyword: EHV; transmission lines; icing; flashover; insulator

1 introduction

Icing is one of the most serious nature disasters. Atmospheric icing on the transmission lines can bridge the insulators and shorten its valuable leakage distance, which distorting the electrical field of the insulators. In addition, with the effect of a high conductivity water-film on the surface of ice, the decrease of electrical performance of ice-covered lead to flashover, line trip and blackout,, which bring significant damage.

China is one of the most severe countries suffering icing in the world. Some serious icing flashover accidents have happened in central China and southern area, such as Hunan, Hubei, Guizhou, Jiangxi, Yunnan, Sichuan, Henan and Shanxi[1,2]. Icing-flashover occupies a large proportion of the icing accidents. With the growing expansion of power grid, an increasing number of transmission lines will be built across the complex environments (pollution, icing, and high altitude) area, where icing flashover accidents happened easily. An investigation report shows that: the frequency and region of icing flashover accidents will have the trend to increase as the construction of power gird development.

Therefore, through the investigation of icing flashovers on transmission lines in the past, and some mechanisms have been reported. Furthermore, based on the summary of present achievements and the analysis of icing flashover, some effective measures against icing can be proposed, which is not just essential to the design and operation of HV, EHV&UHV, but is also able to strengthen the reorganization of icing mechanisms.

Based on the investigation of icing flashover accidents of AC 500kV and DC ±500kV transmission lines, the characteristics and reasons of icing flashover of UHV transmission lines in China were concluded and analyzed. Moreover, with long term observation and research of icing, the methods of icing monitoring and de-icing are also put forward.

2 Investigation of icing flashover accidents of EHV transmission lines

Since the first ±500kV transmission line was built in 1989, the expansion of China's power grid developed very fast. However, the number of icing-flashover accidents of HV transmission line was also on the rise, which posed numerous damages to the safety of the power system. Several typical icing-flashover accidents of AC 500kV and DC ±500kV transmission line are shown below.

(1) During the 12th to 17th, March, 1999, a cold wave attacked Beijing-Tianjin-Tangshan area. 47 times of icing flashover accident occurred on Da-Fang and Sha-Chang line which were both 500kV level owing to a large amount of ice. In December, 2002, Changping, Yanqing areas around Beijing and Guanting in Zhangjiakou were reported to find icing flashovers because of the snow and frog accretions.

(2) On the 8th, March, 1999, the 500kV Tian-Gui Transmission line tripped several times as the icing-flashover which resulted from the melt of ice and heavy frog leading to the disintegration between Southern and Guizhou power grid and a long time blackout.

(3) On the 12th, December, 2001, the phase B of 500kV Ge-shuang Line grounded twice on account of covered ice. Flashover Fault of Equipment in Icing Condition caused the first part of the electrical piano porcelains of the phase B of the ,and the Insulator burned severely.

(4)On the 21th, February, 2001, icing flashover and galloping accidents happened in 500kV Yang-Huai line, which caused to the trip.

(5) In December 2004 and February 2005, the power grid in central China, especially in Hunan and Hubei province, suffered the longest and widest range icing disasters in history. Thousands miles of transmission line were covered ice, which caused the AC 500 kV and the DC ± 500kV line in the power grid of central China tripped several times, and the HV towers collapsed in many areas, the structures were severely destroyed.

(6)In October 2006 and 2007, the Jiangcheng ± 500kV transmission line in Hunan province suffered icing flashovers because of the complex weather mixed by glaze, thick frog and rain.

(7) In 2008, the ice rain weather attacked most of the southern areas in China, leading to an extraordinary damage which is most likely to bring about by the heavy icing of insulators to the power grid. It was reported that 73 trips occurred for the 500kV transmission line due to the icing flashover in Hunan province from October 20th to 29th.

3 The reasons and characteristics of icing-flashover accidents

3.1 The formation and categories of atmospheric icing

It is shown that atmospheric icing mainly consists of glaze, soft rime, hard rime, freezing frog and wet snow, especially; glaze is the most danger to transmission line, and the icing disaster in 2008 in China was caused by that.

3.2 The mechanism of icing-flashover of transmission line

The ice accidents of transmission line can be categorized in mechanical and electrical ways. For the icing flashover, it belongs to the latter one and there are three mechanisms related to it.

(1) Flashovers of insulators bridged by ice

Under the effect of glaze and hard rime, large part of the air gap on the surface of insulators will be bridged by ice, consequently; the leakage distance will be shorten, which reducing the insulation strength. On the other hand, the water film on the ice surface will dissolve the electrolyte in pollution during the ice-melting regime, enhancing the conductivity ice and bringing about the distortion of electrical field. In addition, the air gap distorted the electrical field much more serious, which advancing the propagation of arc and forming the discharge path of leader, eventually; the flashover voltage of ice-covered insulators decrease considerably and icing flashover accident happen. Besides, for the long time rime, snow and hard rime, with the change of meteorological conditions, an alternating process between melting and freeze caused by icing process will come into effect and lead to flashover as well by forming high density ice and icicle.

The flashover of ice-covered insulators caused by bridge is one of the main icing flashover accidents. For EHV&UHV transmission line, because the surface electrical field of insulators is more non-uniform, when ice becomes much worse, its insulation performance will decrease severely. Therefore, the insulator icing flashover of insulators of EHV&UHV transmission line should be paid more attention.

(2) Flashovers caused by freezing frog, acid rain,soft rime and wet snow

Flashovers occurred under these conditions will not bridge insulators. However, the formation of high conductivity water film will also bring about flashovers, and the mechanism under such conditions is similar to that of pollution flashovers. That is, the discharging path is formed mainly by the high conductivity water film on the insulator surface.

(3) Flashovers caused by ice slush and water film

The production of icicle and water film will reduce the electrical strength of other parts of transmission line

significantly, which results in discharge of phase to phase, line to ground, damages of line, insulators, fittings and trip and so on.

3.3 Influences of icing flashover accidents

According to the research achievements and existed analysis of accidents at laboratory and field, insulator icing flashover on transmission line will bring considerable dangers to the operation of HV transmission line.

(1) Icing flashover is unpredicted. Due to the recognition of icing mechanisms of transmission line, the mechanical intensity effects of icing on tower, conductivity and structure are taken into much more consideration than the electrical effects of that, leading to severe icing flashover accidents within the design scope.

(2) Icing flashover will pose great danger to power grid and it is difficult for power system to recover from it. On the occurrence of icing flashover, even reclosing can come into little effect.

(3) Each ice type can lead to serious icing accidents. The present researches are mainly related to glaze for which brings much damage to transmission line. In fact, freezing frog, soft rime and wet snow will be also most likely to cause icing flashover accidents, therefore; they should be paid equal attention as well.

4 Characteristics of icing flashover accidents in China

Based on the recent surveys that icing flashover accidents of AC 500kV and DC ±500kV transmission line occurred in typical region or other area, some features of icing flashover in China can be concluded.

(1) China is a wide country, which has a varied topography and a complex climate. Thus, the area that icing flashover is easy to occur is extremely large. However, most southern provinces and northern regions like Jing-Jin-Tang and Liaoning are often reported to find icing flashover accidents. Moreover, Hunan, Guizhou and Jiangxi province are the most serious regions. In southern areas, the cold air from north and warm air in the south will run into each other here, and static or quasi-static peak area will be formed above mountains, which results in icing easily.

(2) Because of the distributed characteristics of micro-topography and micro-meteorology, the climate conditions of different areas differ from each other. In southern hilly ground and plain regions, most icing flashover accidents are caused by intense freezing rain. In northern plain areas, it is mixed weather like rain and freezing frog that is the main factor to cause icing flashover. In south-western plateau regions, rime and mixed phase ice is the essential blasting fuse.

(3) The types of insulator string play an extraordinary effect on icing flashover. It is shown that almost all the icing flashover accidents of insulators occurred on suspension strings, and there are few reports regarding to strain strings and V strings. This is mainly because that compared with strain strings and V strings; ice on the suspension strings is much easier to bridge insulators. Besides, it is more difficult for the pollution that is on the suspension insulator strings to clean than that on the strain strings and V strings. Furthermore, continuous conductive water film is easier to take shape in suspension strings than strain strings and V strings.

(4) Most icing flashovers happen at daytime during November to February in next year, and few of them are found at night. The reason is that the temperature at daytime is higher than that at night, which is easy to melt ice into water film that is one of the main factors leading to icing flashover.

(5) Icing flashover accidents are characterized by the strong repeatability and hard to recover. Since the discharging path will exist for a long time, therefore; after the trip caused by icing flashover, the reclosing will just plays little effect if the icing environment does not improve.

(6) Recent years, with the development of power grid construction, the number of icing flashover accidents is always on the rise, and it is necessary to take it serious in the terms of design and monitoring.

5 Measures against icing flashover

China has been conducting research of icing monitoring and de-icing since 1950s, and made some valuable achievements in the terms of characteristics and de-icing, which can provide de-icing measures for different

regions that have varied climate conditions. Based on the present research, some advice against icing is proposed.

(1) Observe the icing situation and be aware of the law of icing on transmission line. It is necessary to conduct long term monitoring for the meteorology conditions of varied microclimate area and to acknowledge the icing law of transmission line. Moreover, the icing accidents occurred in the past should be recorded in a detail way. Besides, the design of transmission line should avoid passing through the area that is easy to occur icing flashover as much as possible.

(2) In heavy icing areas, strain strings and V strings should be adopted; for suspension strings, it is necessary to increase the number of insulators to strengthen the insulation performance of transmission line.

(3) During the ice-free seasons, operators should clean the pollution on the insulators to decrease the possibility of icing flash.

(4) To apply devices like equalizer rings to optimize the distribution of field on the icing surface of insulators so that the opportunity of icing flashover can be reduced.

(5) To apply de-icing devices to decrease icing on the insulators, and to develop effective prevention and emergency response ways to reduce the lost caused by icing accidents.

6 Conclusions

(1)The main reasons caused the accidents resulted from atmospheric icing are the production of the icicle and the high conductivity water film. And the paper summarized the three types of the Accidents Resulted from atmospheric icing: the accidents because of the ice bridging the insulator; the accidents resulted is not caused by the ice bridging the insulator; and the flashover is caused by electric strength getting low.

(2)In China, the features of the Accidents Resulted from covered Ice are lasting long time, disturbing widely, and repeating highly. Especially, in some areas, the accidents resulted from covered Ice happened highly and the Accidents resulted from covered Ice easily influenced by micro topography and micrometeorology.

(3)Different types of ice cover all have the possibility caused the accidents. And the different areas have different regularities of the accidents.

(4)Strain strains and V strains have better capability against the accidents resulted from covered ice than suspension strain. For these reasons, in heavy ice areas, it is better to use insulator installed by strain strains and V strains to decrease the rate of the accidents resulted from icing happening.

(5)Using grading rings or other equipments can improve the electric field distribution on the surface of the insulator, so it is better to improve the voltage of the ice flashover to low the rate of the Accidents Resulted from ice happening.

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